US Army Corps
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Report on Special Investigation of Bed Sediment Segregation in a Degrading Bed

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SUMMARY AND CONCLUSIONS

The findings from this study are summarized as follows:

1. In an equilibrium bed in which non-moving particles are present the non-moving particles segregate from the layer of moving bed material and form a coarse sublayer.

2. This sublayer is well defined, smooth in profile, and approximately the thickness of the average non-moving particle.

3. This sublayer seems to interfere with the equilibrium transport of the moving grain sizes; it is believed it tends to equalize the relative rate of transport, $\frac{i_t q_{st}}{i_b}$, for all moving sizes.

4. The Einstein relationship for the rate of transport predicts very well the limiting grain size ($\Psi_* = 27$) larger than which there is no transport.

5. When a bed containing non-moving particles is allowed to degrade, the non-moving particles accumulate at the bed surface reducing the area of the bed from which particles are scoured.

6. The reduction in the rate of transport is found to be proportional to the accumulation of non-moving particles.

7. Non-moving particles in a partial pavement or a pavement arrange themselves in a characteristic "shingled" formation.

8. If this characteristic "shingled" arrangement is disturbed, the "non-moving" particles will move until they are rearranged in a new "shingled" pattern.

9. Non-moving and extremely slow moving particles in a degrading bed move downstream as they move downward. The resultant direction of this motion can be expressed as a slope with the bed surface; the

order of magnitude of this slope for the non-moving particles was found to be 0.01.

10. This motion of the "non-moving" particles may prevent the formation of a complete pavement in a short flume (Experiment C), but this effect has only local significance in a river.

11. The accumulation of non-moving particles on the bed surface causes an increase in its effective roughness, k_s, and, in the experiments, increased also the limiting grain size for non-movement.

12. It is estimated that in a river this increase in roughness will not increase appreciably the limiting grain size for non-movement; an increase is likely to occur only if there is an increase in the energy slope during the degradation process.

13. It has been found that a layer of non-moving particles the thickness of one particle is effective in preventing scour. It is felt that a complete layer of non-moving particles is not necessary in all cases; for a layer of non-moving particles with values of Ψ_* ranging from 27 to 40, only 50 percent completeness is probably required, while a more nearly complete layer is required if all particles are on the verge of movement ($\Psi_* \sim 27$).

14. The Einstein relationship shows the relative rate of transport, $\frac{i_t q_{st}}{i_b}$, to increase from zero for the large grain sizes to a maximum at grain size, D_m, and to decrease for the smaller grain sizes. In a degrading bed it has been found that this relationship expresses very well the relative rates of transport for grain sizes larger than D_m; however, the transport of the smaller grain sizes is governed by their availability in the bed mixture, and the values of $\frac{i_t q_{st}}{i_b}$ for grain sizes smaller than D_m remain constant at the value for D_m.

The following recommendations are made for a continuation of the study of degrading beds:

1. Computation using existing experimental data to determine the thickness of the active bed layer to assume for the purpose of calculating the change in composition near the bed surface during degradation.

2. An experiment similar to those of this study with the following exceptions:

a. Use of a natural river bed mixture with not more than 1.5 percent of particles which do not move in equilibrium.

b. Alteration of the experimental procedure to eliminate the effect of the loss of non-moving particles as outlined in Chapter 15.

3. Experiments in which roughnesses, either artificial roughnesses or large particles, are superimposed on a movable bed surface and the amount of these superimposed roughnesses necessary to prevent all transport is determined. (See Chapter 18).

4. Experiments in long flumes for the purpose of determining how to calculate the degradation process on rivers where the degradation is not uniform.

5. An experiment similar to those of this study with uniform bed material and with bed mixtures containing no non-moving particles.

6. An experiment similar to this study in which varying discharges are used during degradation.

7. Experiments on both equilibrium and degrading beds, with and without non-moving particles, to determine the layer thickness that takes part in the transport.

8. Collection of data from natural rivers that are degrading and correlation of this data with experimental results.